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ORGANIZATION OF CARTOGRAPHIC SERVICES
IN DEVELOPING COUNTRIES

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A.1.2. ORGANIZATION OF CARTOGRAPHIC SERVICES IN DEVELOPING COUNTRIES

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Par. 1. Introduction.

With the exception of such services in which the administrative aspects are more important than their cartographic activities, such as land registration and cadastre, the character of all cartographic organizations is more and more being determined by the application of aerial survey. It may be that there still exist a large number of small offices, mainly private, which use ground survey methods only, the most important government services and the larger private organizations, however, apply air photography to their cartographic problems. Therefore we will deal in this paper only with the organizations of aerial survey services.

Airplanes, airborne equipment, such as photogrammetric cameras and auxiliary instruments, photogrammetric restitution instruments and the many other items of equipment required to carry out effectively any photogrammetric task, are quite expensive, both to purchase and to use. The capital cost alone of establishing an organization to engage in photogrammetric work, even an organization of very restricted scope, is such, that, compared with terrestrial survey methods there is much less possibility of small organizations coming into being. Thus there is an almost irresistible tendency towards centralization of photogrammetric establishments in a small number of large and well-financed organizations. This tendency is as applicable to government as it is to private organizations. In the past the cost of equipment could be computed as a percentage of the annual salary of one man. This is changed entirely now and consequently the present tendency is away from the individual surveyor and towards the team.

Where the task is associated with general topographic mapping for military purposes and for other purposes connected with national planning, a centralized government service is usually created, frequently under military control. The necessary capital investment finds an appropriate place in the national budget. In the more varied and specialized fields of project mapping for purposes associated with engineering, with agriculture, with cadastral requirements and with other needs, a degree of decentralization is both possible and evident in some countries. Even here, however, the high capital cost coupled with a rather exacting requirement for personnel, combine to limit the practicable degree of this decentralization, regardless of whether the work is carried out by government or by private organizations.

Par. 2. Organization of Government Services.

The distinction between general topographic mapping and specialized project mapping raises the question whether one or two organizations should be created. While the equipment and the technical knowledge of the personnel, required for project work, will be dictated by the particular nature of each project resulting in the use of a variety of methods and equipment, these requirements will vary for general topographic mapping only according to variations in the terrain. Consequently the choice is between either two separate services or at least separate branches of the one centralized service. Experience taught the author that in services in which both branches are combined, the great need for project maps sets back the general topographic map of the country. In addition to this danger we believe that also for the different technical procedures which must be applied for the production of a topographic map and for the wide variety of large-scale technical and administrative maps, the establishment of two different services should be recommended.

Both these branches, however, should make use of the same centralized flying organization. This may be either an independent organization, a branch of one of the photogrammetric divisions, or of an overall organization for aerial survey. In some countries this task is entrusted to the regular military photographic division of the air force. This solution is not favoured by the author, as there is an ever-increasing difference between the requirements of air photography for civil and for military purposes. The military requirements of fast aircrafts with a high ceiling, while it may be suitable for general mapping at very small scales, is quite unsuited for larger scale project works, where low flying heights and, in particular, low speeds of flight are becoming more and more essential. Furthermore a stable organization of well-trained specialized personnel, possible in a permanent civil service is far more difficult to obtain in a military service, at least at the commissioned rank level.

In some less developed countries in which no well-equipped air photographic organization exists, the necessary airphotographs are obtained by means of public tenders invited on the international market. Although in that case nearly always first-class photography is obtained, the great disadvantage of this method is that a great mass of air photographs is delivered at the same time which cannot be mastered by the cartographic service of the country within a reasonable delay.

It may be mentioned that specially the project mapping branch will need the continuous presence of a photographic airplane with crew for the production of various kinds of large-scale photographs required for a wide variety of engineering, agricultural and other projects. Unfortunately this photographic unit is in almost all developing countries the weakest spot in their aerial survey organization. Either there exists nothing or the air photography is entrusted to the military air force which in many cases has no skill in this kind of work and furthermore is not under the command of the cartographic service. The result is that in several countries the air photography is the bottleneck of photogrammetric map production. Efficiency is hampered by poor navigation and, in many cases also poor quality of the photographs. In the paper K.1. 2. and K. 2. 3 Specialized Training as a means of accelerating the formation of Scientific and Technological Cadres, we will deal with the possibilities of training of air photographic staff as a group of specialists.

It may be accepted therefore that whether the organizations are all branches of the one department or whether they are autonomous to a certain degree, there will generally be a need for three categories of organizations for carrying out the cartographic work required in any country for government purposes, using air survey. These will be:

- 1) The general topographic service.
- 2) The Project Mapping Service.
- 3) The specialized flying and photographic organization.

The Project Mapping Service must have a relationship to client departments very similar to that of consultant or contractor to client in civil matters. It should maintain an effective liaison with departments, responsible for the design of roads or the registration of cadastral information, with local government authorities or with departments of agriculture, forestry, geology or others concerned with the assessment and development of natural resources. Whether specialists in the various fields (soil scientists, foresters and geologist, etc.) are employed by the Cartographic Service or by the respective client department is a matter of detail which will depend on the preferences of the people concerned and on the general public service structure existing in each particular country. The important condition, however, is that there exist close ties and a good coordination between all organizations of the country concerned with cartography or with the use of air photographs. A cartographic council or a geodetic committee consisting of representatives of ministries and services, dealing with cartographic matters and of scientists in those fields from the universities, can render excellent services for coordination of the cartographic activities of developing countries.

Par. 3. Organization of Personnel.

Although we will not deal with these matters in great detail, it must be realized that they are extremely important and that the points to be considered are applicable equally to government and to private organizations. Many of the matters mentioned come within the sphere of personnel management of which quite an extensive study is warranted, both by private enterprise and by governments and in which experts advice should be sought.

In the field of mapping, as in any other field, be it technical or administrative, the organization of personnel cannot be considered as a problem separated from the training of that personnel, and the organizations must make adequate provision both for the training of personnel at all levels and for the reasonable advancements of the personnel so trained. Achieving this state of affairs in any particular organization is a matter of detailed analysis of the requirements both present and future and only general guiding principles need be enunciated here.

Each section of an organization must of course, be built up from its component part, which will be determined by the functions which it should discharge within that organization.

This is also valid in a cartographic organization in which we will consider the various sections which should exist within such an organization. Those sections are the following:

- 1) General management.
- 2). Planning and costing.
- 3) Air photography.
- 4) Control.
- 5) Mapping.
- 6) Photographic Laboratory.
- 7) Cartographic section.

We will pay attention to each of these sections. They have in common, however, that the section heads (in a government service they may be designated chief of division) of such an organization must all be men of high technical competence and a wide experience both in the specialized technical field and in the administration of a section of an organization.

It is obvious that the organization we have in mind should be of such a magnitude that it should be able to carry out mapping projects of any size and scope. For smaller organizations some of the sections naturally can be combined and the number of section heads reduced in accordance with this.

a) General Management.

In the case of a Government service this section would be headed by the director of that service, who would be responsible to an appropriate ministerial or departmental head. In either case this director would receive instructions on matters of policy from the authority to which he is responsible and his section would be charged with the implementation of that policy with the administration of the whole organization and the apportionment of tasks to its component parts. All other section heads will be responsible to this director and it will be his responsibility to ensure that there is an adequate liaison between the various sections on all matters of common or overlapping interests.

b) Planning and costing.

The head of this section should be the most senior from the point of view of status in the organization and the most experienced technical section head in the organization after the director. This section will be responsible for a systematic analysis of all proposed projects both in their technical aspects and in regard to cost. In addition the costs of all current work must be assessed and analysed in this section, as must the suitability of any suggestions from other sections regarding possible improvements in techniques or methods, either in use or proposed. Regular reports must regularly be made to the general management on all these matters, in addition to special reports as either called for or as may be seen to be desirable. In organisations having a capacity sufficient to carry out research for improving methods in use, the planning of this research must also be entrusted to this section. A cooperation with the section in charge of the subject concerned must be accepted, in planning as well as in execution of this research project.

c) Air Photography.

The head of this section (or sub-section if it is attached to Planning and Costing) must be a man with considerable aircrew experience and with a wide general knowledge of the problems associated with photogrammetry as they effect the flying mission. In some countries we find the combination of this section with the photographic laboratory, and this combination has advantages in smaller services. The photographic engineer will then also be trained as a navigator and act as chief of the section. Even more important to him than knowledge of general photogrammetric problems is knowledge of the scientific background of air photography in order for him to make a balanced assessment of the elements which will influence the quality and utility of the photographs which his section produces. If these provisos are satisfied, it will almost always be the Photographic Engineer - Navigator who will be head of this section and be in charge of the photographic mission.

d) Control.

This section will be responsible for the detail planning and the provision of all control, both ground control and densification by way of aerial triangulation. The provision of ground control involves the application of techniques, and the use of equipment, for ground survey, quite different from those employed in other types of ground survey associated with the photogrammetric production of maps. The execution, computation, and adjustment, of the necessary aerial triangulation, will also be carried out in this section. The section head, therefore, must be a photogrammetric engineer of considerable experience, but also a very sound knowledge, both theoretical and practical, of geodesy, will be a necessary pre-requisite.

e) Mapping.

This section will be responsible for carrying out all plotting work, and associated field sur-

vey such as pre-reconnaissance and completion surveys. Control provided by the Control Section will be used for this purpose, and there must, of course, be an adequate liaison between these two sections. The technical qualifications and experience of the personnel in this section will not need to be of such a high order as those of the personnel of the Control Section, and there will be opportunities of advancement, at many levels of staffing, from the Mapping to the Control sections. In those countries where field work is only possible at certain seasons there are obvious advantages in having all professional personnel trained both for photogrammetric plotting work and for field survey, so that each operator can carry out the field checks associated with his own plotting work.

In this section attention must be paid to the problem of work in shifts. In particular in less developed countries with low wages and high capital investment in photogrammetric equipment, working in shifts will be a logical consequence of the proportion between these two elements of cost of mapping. The same consideration is valid for the aerial triangulation in the control section. Working in two shifts of between 6 and 7 hours each, should be normal.

f. Photographic Laboratory.

This section will be responsible for all photographic laboratory work, including the processing of negatives, production of diapositives, paper prints, rectified prints, mosaics, etc. This section may in some cases be combined with that of air photography.

Unfortunately in some services and enterprises photography is still considered a kind of handwork of an empirical nature, and is entrusted to personnel without much scientific education, who can at best be considered as highly skilled labour. The recent development in the evaluation of photographic qualities may convince authorities that the requirements regarding education of the head of such a section is not less than for the geodesist and photogrammetrist.

g. Cartographic Section.

In many photogrammetric services the end product will be a fair drawing of the manuscript, produced by the mapping section, either by inking or preferably by engraving or scribing. This will be the case in particular in those services which are mainly engaged in project mapping for engineering and other purposes projects. In such cases reproduction is carried out by means of direct contact copying on diazo-materials in one colour, although at present the same procedure can also result in prints in two and even three colours. In such services it will not be worth while to organize a cartographic section for reproduction. This will be necessary only in those services where larger editions of multicolour maps are required, and will generally be entrusted to a separate branch of the organization. The reproduction branch of a topographic service is highly specialized and goes beyond the scope of this paper. In some countries there are even special organizations with a separate management. As a consequence of the fact that a technique of reproduction is entirely different from all techniques required for the production of the manuscript, we consider this beyond the scope of this paper.

Par. 4. Training of Personnel.

In the great majority of cases training and education in the field of photogrammetry takes place in the service itself. Photogrammetric restitution is considered a highly specialized profession in this sense, that the photogrammetric operator does not need much more education than is necessary to handle his equipment. The extreme examples are the hundreds of Kelsh operators in some parts of the world, who consider themselves photogrammetrists and unfortunately are also called photogrammetrists by others. Their basic education is limited

to the problem of orientation in a Kelsh Plotter. The interpretation of the stereoscopic image in such a way that the fully justified representation of the topographic features of the terrain will be the result of the restitution should, however, also be based on a special study of geomorphology.

With regard to the education of responsible staff members of many of the photogrammetric services it should be mentioned that nearly everywhere photogrammetry is a subject and not the most important one, in a civil engineering course. On the European Continent and in Russia the situation in this respect is better, since there are special degrees in geodesy. In these courses an increasing stress is laid on photogrammetry. This combination of a higher education in surveying and photogrammetry is essential for leading staff members of cartographic services of today.

The consequence of this broader education of surveyors and geodetic engineers with a university degree in surveying, is that several of them are following at present specialized post-graduate courses in photogrammetry as offered by special institutes, in order to arrive at the best possible combination for a leading photogrammetrist.

In the field of technicians and operators there are two possibilities to obtain personnel: either to give survey technicians a photogrammetric training or to include sufficient elements of surveying and field work in the education of photogrammetric operators.

A photogrammetric operator who does not know either how the field really looks or the fundamental operations of measuring angles and distances in the terrain with the additional elementary computations, is only a poor photogrammetric technician and because of the narrow field of his knowledge, a danger to himself. Consequently in each specialized course for photogrammetry at least the elementary surveying problems must be included.

Another problem is whether this training should be organized in special courses or whether it is sufficient to let the trainee straightaway take part in productive work and give him the task of mastering the theory on his own from instruction books and discussions. It is our experience that the last method is not sufficient. Whether a future photogrammetrist is sent to special courses outside the service or whether the service is large enough to organize special courses itself, is of secondary importance: the main point is that special courses are organized which make that afterwards a technician and an operator feel that their knowledge and experience are more than adequate for everyday work.

Par. 5. The role of private enterprise.

It is not difficult to understand that private enterprise, even in the early stages of the development of aerial survey, tried to sell this new method and its advantages both to Governments and to private organizations in various countries. The commencement was naturally with aerial photography, which was followed by the introduction of plotting from photographs. In this way private enterprise has played a role in the promotion of photogrammetry and it is continuing at present along the same lines. In several less developed areas and in new states foreign private enterprise has rendered services to the governments of these countries by providing them with the necessary maps and photographs required for development projects far beyond the production capacity of a national cartographic service in its early beginning.

Although at present many of these countries do their utmost to improve their national cartographic services and particularly invest not only money in equipment, but also in training of the national manpower, still, it must be admitted that in many cases there exists a gap between the production capacity of these new services and the need for maps and photographs of these countries. Consequently there still remains an important task for private organizations.

Since the role of private enterprise in cartography is, in particular in less developed countries, important, a paper dealing with problems of organization of cartographic services should mention a few of the principal considerations for and against the use of private enterprise for mapping. They are as follows:

Advantages:

- 1) Provided that the specification truly specifies the requirements, a tender will mobilise the most efficient means of satisfying those requirements, which may be available to the various enterprises which submit quotations.
- 2) It may be that, even if an organization is established in the country, the methods and equipment available to this organization may be less suited to the requirements of the job than those available to some other company.
- 3) Where maps are required in addition to normal production, it may be preferable to have them provided by contract, rather than to consider the alternatives of either extending the existing organization, with an inevitable loss of time, or interfering with the regular job of that organization.
- 4) Generally speaking, although there will doubtless be some who will contend to the contrary, the cost of a job carried out by private enterprise will be less than the cost of the same job done by a government service, particularly in the case of competitive tendering.

The disadvantages, or what are frequently considered to be the disadvantages of contract work, are as follows:

- 1) Funds must be made available on the departmental estimates for the project, as such, which involves a necessity which is sometimes thought to be irksome, of making out a case for the project concerned. In the case of work carried out directly by an established government organization, the required budgetary provision will be made as a matter of course, in the normal departmental estimates for salaries, etc., and although the cost of a project is unlikely to be less in this way, there is unlikely to be a need to make out a particular case for the project.
- 2) An intensive control of quality must be carried out, which while easy for photographs, is very tedious and complicated for maps. If a tolerance is specified in the form of a mean square error, it will be necessary to check at least two hundred points. In this case, the clause may be interpreted to mean that no more than 5% of the points checked should exhibit errors exceeding twice the specified mean square error. No absolute tolerance should ever be specified, and no reputable contractor would ever tender on such a basis.
- 3) The time necessary for the check will be so long that, in practice, only a few tests will be made, and the control will generally be found to be unsatisfactory.
- 4) Difficulties will arise, both with the contractor and with the agencies requiring to use the maps, should the tests disclose a negative result. These agencies will generally be reluctant to accept the inevitable loss of time involved in improving the precision of the result by establishing more ground control and repeating the photogrammetric operations. This danger, and that mentioned in 3) above, suggest that a restricted list of contractors, known to be both competent and reputable, should be invited to submit tenders, or alternatively that there should be a stipulation in the tender notice that the principals reserve the right to accept or reject any tender, and not to be bound solely by a comparison of the prices submitted.
- 5) With the exception of photography and ground survey, the most efficient use of the organization of the contractor will generally require that the bulk of the work should be carried out in the country in which the contractor is established. Here again it will be necessary to have confidence in the integrity of the contractor concerned.

It is obvious that comparison of the advantages and difficulties listed above do not allow to

draw a conclusion about the desirability to make use of private enterprise. It will require a thorough study of the circumstances under which a certain project must be carried out, of the quality of the contractors willing to offer a bid on a tender and especially of the list of specifications for such a tender, before a decision can be taken.

Specially the description of the method of checking of the results presented by the contractors is important. The application of a scientifically justified sampling method and a close cooperation between the checking authority and the contractors organization can eliminate a great deal of the disadvantages mentioned above. Independent expert advice will in many cases be a wise policy in order to protect not only the government agency, but in some cases also the contractors.

